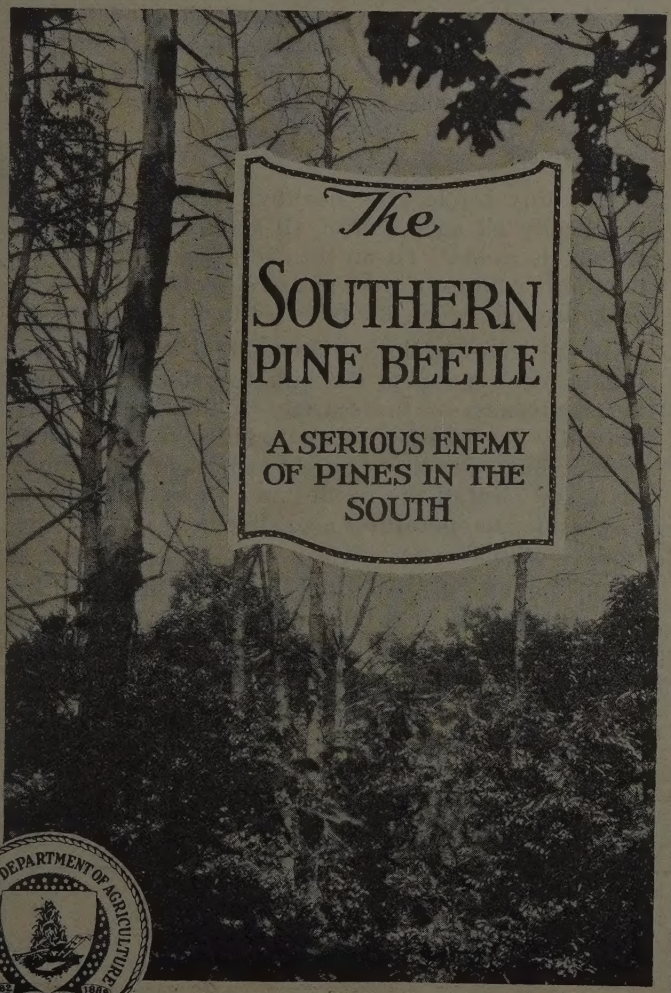
E & A
R
IMP. BUR.
8 Aug. 1924
ENTOM

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1586



The SOUTHERN PINE BEETLE

A SERIOUS ENEMY OF PINES IN THE SOUTH

THE PERIODIC widespread devastations of the southern pine beetle have been responsible for the destruction of more merchantable pine timber in the Southern States than has any other agency. During a single epidemic it has destroyed timber valued at $2,000,000, and the present stumpage value of pine killed since 1891 is placed at no less than $50,000,000.

This tiny beetle kills healthy, vigorous pines of practically all ages and of all species which occur within its range. To do this, it attacks the middle to upper portions of trees and destroys the soft inner bark through which the trees get their nourishment.

Recent investigations indicate that weather conditions have much to do with the abundance and destructiveness or the scarcity of this beetle. Abnormally dry weather seems to be followed by outbreaks, but when the drought is broken by normal or heavy rainfall the beetle may almost disappear. Low winter temperatures also effectively check these beetle outbreaks.

This bulletin describes the insect and its work, its life and habits, and the methods that have been employed to prevent and suppress outbreaks. It supersedes Farmers' Bulletin 1188, The Southern Pine Beetle: A Menace to the Pine Timber of the Southern States.

Washington, D. C. Issued May, 1929

THE SOUTHERN PINE BEETLE: A SERIOUS ENEMY OF PINES IN THE SOUTH

By R. A. St. George, *Associate Entomologist*, and J. A. Beal, *Assistant Entomologist, Division of Forest Insects, Bureau of Entomology*

CONTENTS

	Page		Page
Beetle outbreaks and their importance	1	Natural enemies of the southern pine beetle	15
Evidence of beetle attack	3	Preventive measures by forestry methods	15
The beetle: Its work and its life throughout the year	4	Control measures	16
Bark beetles likely to be mistaken for the southern pine beetle	8	Investigations of outbreaks	18
Other beetles associated with the southern pine beetle	13		

BEETLE OUTBREAKS AND THEIR IMPORTANCE

EVERY FEW YEARS patches of dying and dead pines may be seen throughout the southern forests. These group killings can usually be attributed to a bark beetle known as the southern pine beetle.[1] Ordinarily it is a rather rare insect, breeding in small numbers in weakened and dying trees. Periodically, however, favorable conditions occur for development of its broods, enabling it to increase in a very short time from a few individuals to countless hordes. Results of recent investigations of the Bureau of Entomology indicate that abnormally dry spells bring about favorable conditions for outbreaks, both by weakening the trees and by creating a more favorable situation in the inner bark for the rapid development of the broods of the beetle. The resumption of normal or heavy precipitation effectively checks such development and very nearly eliminates the beetle from the forest. Low winter temperatures also effectively check the increase of the beetle.

Other agencies which affect the trees, making it easier for the beetles to overcome their resistance, are fire, wind, and lightning. Trees weakened by these agencies, or by mechanical means, constitute a menace to the surrounding forest. Many infestations owe their origin to the attractiveness of a single weakened tree; therefore such a tree should be removed immediately. During periods when the beetles are present in small numbers, abnormal trees enable the bark beetles to establish themselves and breed up to normal numbers, whereupon they again can become destructive, killing groups of surrounding healthy trees. Results of recent studies suggest that trees

[1] *Dendroctonus frontalis* Zimm.; order Coleoptera, family Scolytidae.

on burned areas serve as an attraction to the beetles. This is an additional reason for adequate fire protection. "Blow downs" occurring during the summer, as well as the large quantities of timber normally cut at this time, also create conditions which are a menace to the surrounding healthy trees. This freshly cut or damaged timber is frequently attractive to the beetles.

There is probably no more serious enemy of pines in the Southern States than this beetle. It attacks and kills healthy, vigorous pines

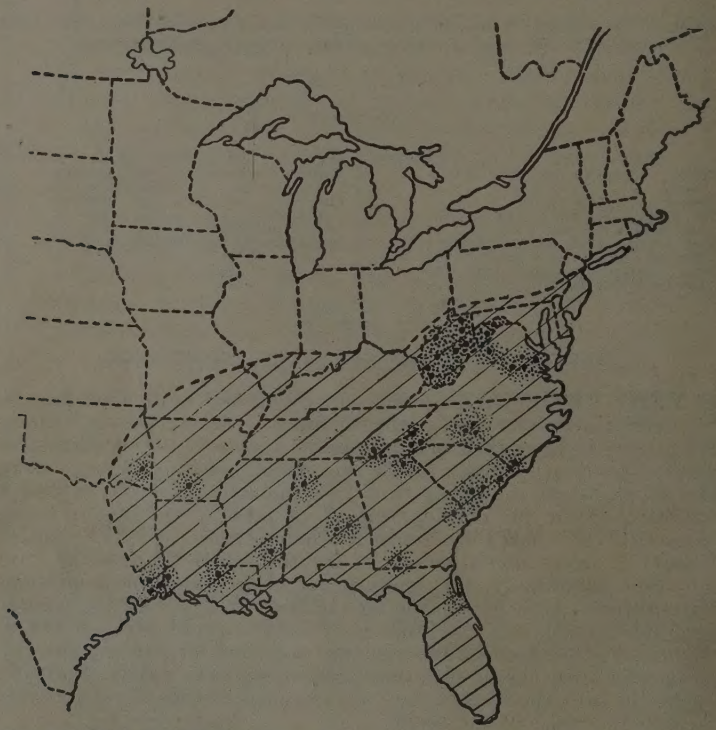


FIGURE 1.—Map showing distribution of the southern pine beetle. The dots represent known centers of infestation

of all species occurring within its range, including those of practically all ages. Extended observations in the Southern States since 1891 have led forest entomologists to place the present stumpage value of pine killed during this time at no less than $50,000,000. Hopkins [2] places the value of timber killed by this beetle, during a single epidemic in the South Atlantic and Gulf States in the years

[2] HOPKINS, A. D. THE SOUTHERN PINE BEETLE: A MENACE TO THE PINE TIMBER OF THE SOUTHERN STATES. U. S. Dept. Agr. Farmers' Bul. 1188, 15 p., illus. 1921.

1908 to 1911, inclusive, at $2,000,000. In 1922 and 1923 extensive outbreaks of this beetle were again reported or observed, and a vast quantity of timber was known to have been killed. The latest outbreaks took place in 1925, 1926, and 1927. It is well known that only a comparatively small percentage of the destroyed pine was ever salvaged after these epidemics. There is constant danger that the beetle status may again rise to the danger point.

No part of the South is free from this bark beetle. Its outbreaks occur periodically throughout the States of Georgia, Alabama, Mississippi, Louisiana, Texas, Arkansas, Tennessee, Kentucky, South Carolina, North Carolina, Virginia, West Virginia, Maryland, and Delaware. The beetle is also known to occur in the southernmost

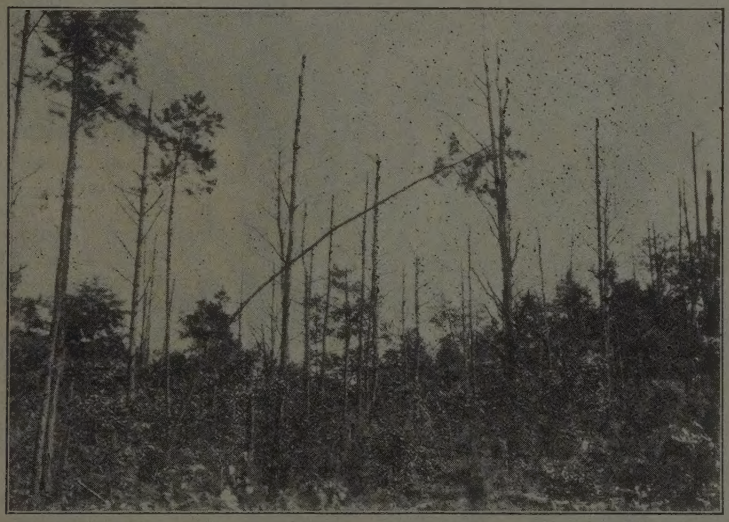


FIGURE 2.—A group killing by the southern pine beetle. Appearance of forest area several years after the trees were killed. Note the new growth

portions of New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Missouri, eastern Oklahoma, and northern Florida. Centers of infestation and distribution are shown in Figure 1.

EVIDENCE OF BEETLE ATTACK

Wherever patches of dying or dead pine are found (figs. 2 and 10) which show no evidence of fire or other destructive injury, there need be little doubt that they have been attacked by the southern pine beetle. These trees can be discovered most easily after they have been infested from 10 days to two weeks, when they display a yellowish-green foliage easily seen from long distances. The color gradually turns to a brownish green, and finally, about the time the beetles emerge, to a reddish brown. Pitch tubes often occur along the

middle and upper trunk (fig. 3), but they should not be confused with the larger tubes of the turpentine beetles[3] which are found near the ground. (Fig. 15.) Reddish sawdustlike borings can often be found sprinkled along the trunk and on the ground around the base of the tree. A blue-stain fungus which results in lowering the grade of salvaged lumber is always associated with trees killed by this beetle. (Fig. 4.) The stain quickly extends to the heartwood. (Fig. 5.)

FIGURE 3.—Pitch tubes made by the southern pine beetle along the middle trunk. About one-half natural size

Where any doubt exists as to the species attacking the trees, close examination of the inner bark from the middle of the trunk of the dying trees will positively determine the insect. Here the characteristic winding, S-shaped galleries in the inner bark (fig. 6) and on the surface of the wood (fig. 7) can be found, and by removing a portion of the outer bark the developing broods can be seen. The burrows of the grubs, or larvæ, extend only about half an inch from the parent gallery. Here the larvæ make oval cells in the outer bark and go into a resting stage—that is, become pupæ, before transforming into beetles.

THE BEETLE: ITS WORK AND ITS LIFE THROUGHOUT THE YEAR

Like most insects, the southern pine beetle passes through four distinct stages during its life history. These are the egg, the larva, the pupa, and the adult. The adult (fig. 8, at right) is a small brownish or blackish beetle about one-eighth inch long. It flies throughout the year except during the cooler winter months, when it remains dormant within its galleries beneath the bark. It usually attacks the

[3] The red turpentine beetle (*Dendroctonus valens* Lec.) and the black turpentine beetle (*D. terebrans* Oliv.)

FIGURE 4.—Blue-stained, dead trees. The blue stain is alway associated with trees killed by the southern pine beetle

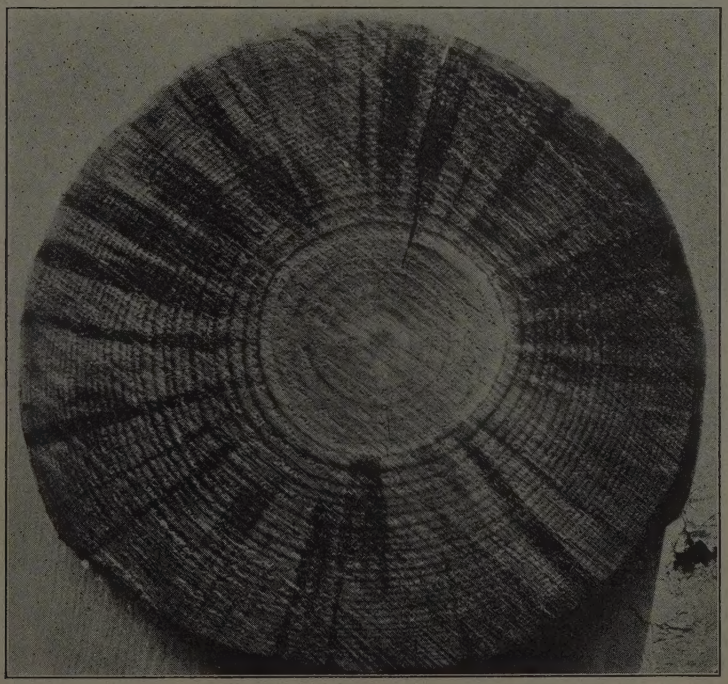


FIGURE 5.—Cross section of pine tree killed by the southern pine beetle, showing the associated blue stain extending to heartwood, causing a lowering in grade of merchantable timber

central and upper portions of healthy pine trees (see title-page illustration) as well as weakened trees and occasionally girdled trees and felled logs. Sometimes the attack on standing trees extends almost to the ground. The beetles bore in through the bark and excavate long, winding, S-shaped galleries (fig. 7) which extend through the inner layers of the living bark and mark the surface of the wood. They deposit their eggs in small niches along the sides of the galleries. From these eggs young grubs, or larvæ (fig. 8, at left), hatch and feed on the inner bark (fig. 6) until full grown, when they mine into the outer bark, excavate cells, and transform to the pupal or resting stage. In from 7 to 10 days they change to adult beetles and emerge from the tree through tiny exit holes. (Fig. 9.) The beetles then fly to other living trees or occasionally to suitable logs, where they lay eggs to start the next brood. They pass the winter in all stages of development, between the bark and the wood or in the bark itself. The trees that harbor them may be living, dying, or even dead. The more advanced beetles begin to emerge and fly in the spring about the time the redbud[4] blooms, and the later ones continue to develop and emerge until midsummer when the blackberries begin to ripen. Trees attacked during the previous fall are dead and abandoned by the beetles before the following July. (Fig. 10.) Those attacked during the early part of the summer are dead and abandoned by midsummer of the same year.

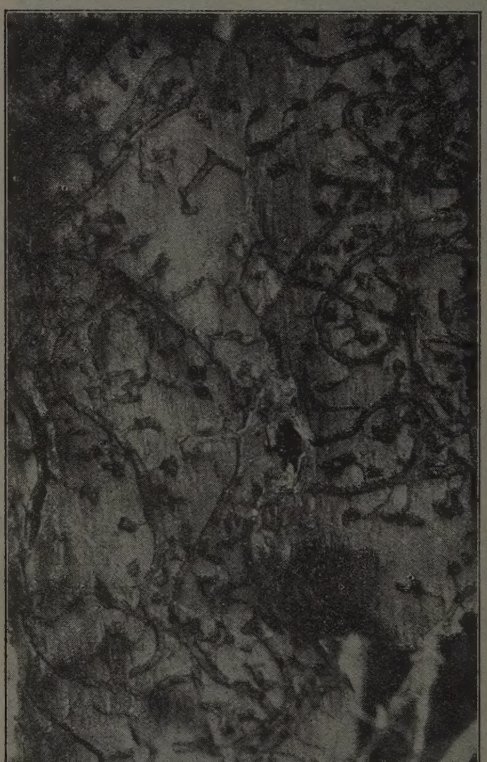


FIGURE 6.—S-shaped galleries made by adults of the southern pine beetle in the inner, soft bark of pine. Note the oval larval or grub cells about one-fourth to one-half inch on each side of the egg tunnels. Slightly reduced

[4] *Cercis canadensis* L.

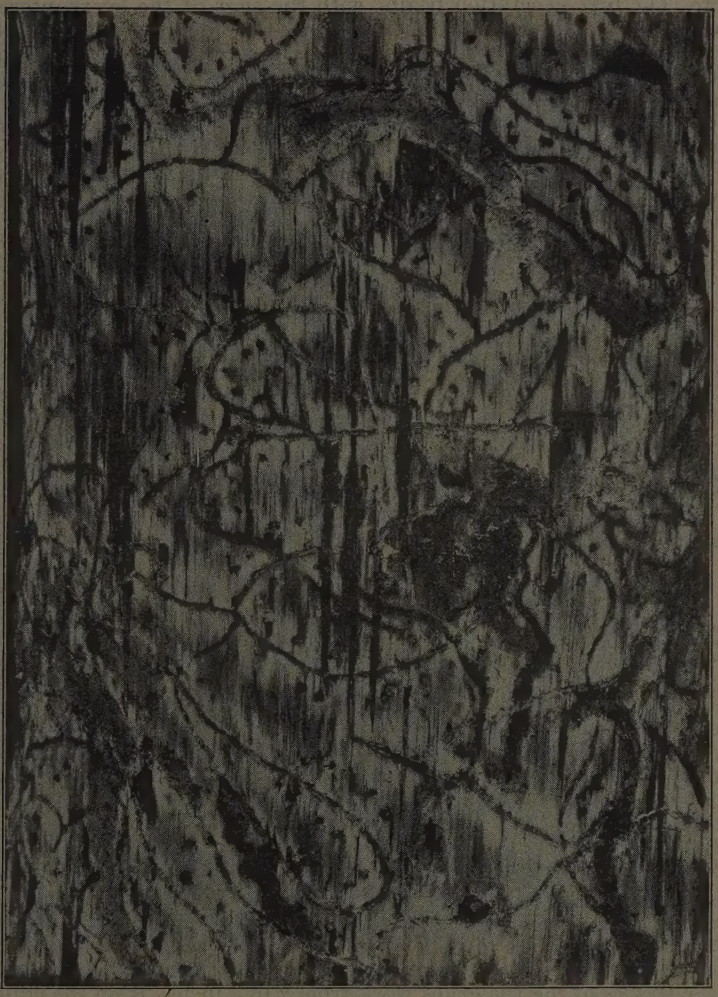


FIGURE 7.—S-shaped adult-beetle galleries marking the surface of the wood. The larger ones are those of the southern pine sawyer, which often destroys many of the broods of the southern pine beetle. Slightly reduced

From three to five generations occur annually, the number of generations depending on the section of the country in which the beetle occurs, the length of the summer season, the climatic conditions, and the vigor of the beetles. Flight begins in the spring and early summer. The first generation begins with the eggs of the overwintered beetles. When the larvæ from these eggs have developed into adult beetles the first generation is complete. The second generation begins with the eggs laid by the newly formed beetles, and so the process continues until checked by cold weather.

Under favorable conditions a brood can develop from egg to adult in from 30 to 40 days, and the number of beetles can increase as much as 1,000 per cent in a single generation. With the possibility of producing five generations a year, the beetles' capacity for increase and for starting sudden outbreaks is very great.

FIGURE 8.—A, mature larva and, B, adult of the southern pine beetle. Greatly enlarged. (The vertical line indicates the natural size of the beetle.) (Hopkins)

BARK BEETLES LIKELY TO BE MISTAKEN FOR THE SOUTHERN PINE BEETLE

A great many other bark beetles are often associated with the southern pine beetle, but in this bulletin only those most likely to be confused with our most serious enemy of southern pines will be mentioned, namely, the turpentine beetles and the Ips bark beetles.

The Ips bark beetles can be distinguished from the southern pine beetle by the form of the body and the type of tunnel they make. The chief difference between them is seen in the form of the posterior end of the abdomen. In the southern pine beetle this is gradually rounded out in a convex manner (fig. 11, A), whereas in the Ips bark beetles it is scooped out and armed on both sides of this depression with minute toothlike projections. (Fig. 11, C and D.) The egg galleries of Ips are straight or star shaped (figs. 12 and 13), whereas those of the southern pine beetle have a characteristic serpentine, S-shaped appearance. (Figs. 6 and 7.) Furthermore, the grubs of the southern pine beetle bore for a distance of about one-half inch from the parent tunnel and mature in the outer bark, whereas most of the species of the Ips grubs work from 2 to 3 inches from the adult gallery and mature between the inner bark and wood. One very small species of Ips [5] works near the top of the tree and makes a larval mine about one-half inch long like that of the southern pine beetle, but this work can be readily distinguished because the adult gallery is comparatively straight and not S-shaped. (Fig. 14.)

[5] *Ips avulsus* Eich.

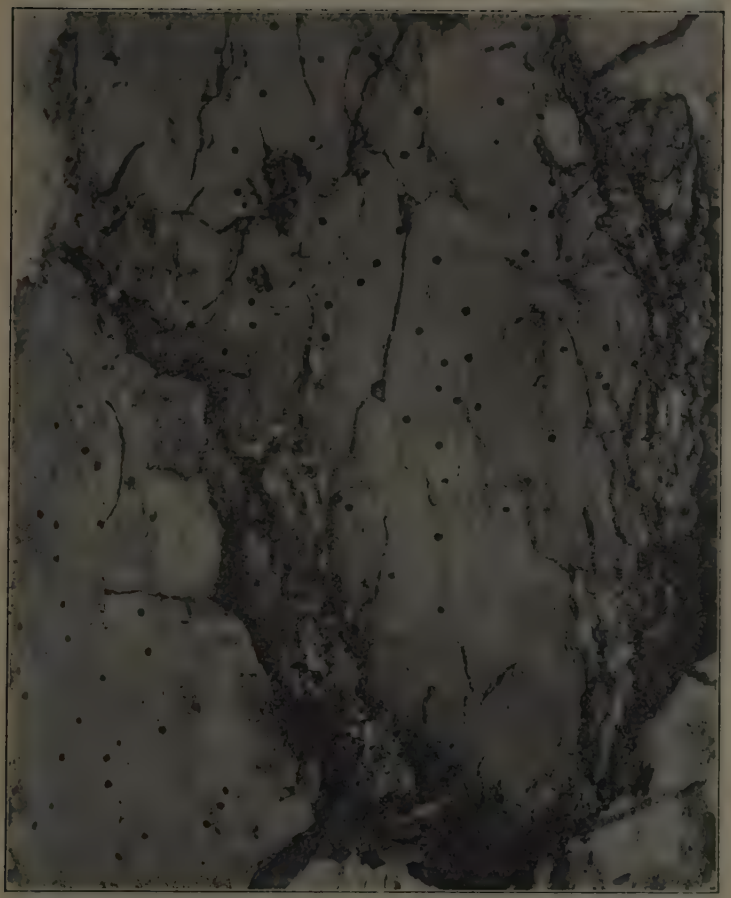


FIGURE 9.—Exit holes made by new southern pine beetles emerging from the bark. About two-thirds natural size

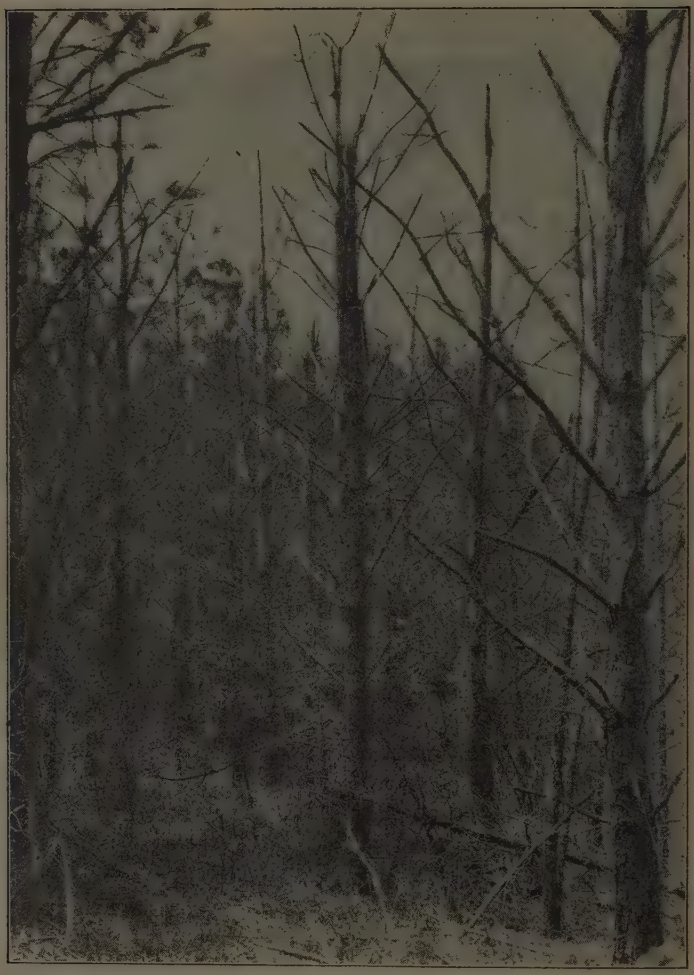


FIGURE 10.—Trees abandoned by the southern pine beetle soon after being killed

This difference in habits is made use of in control of beetle outbreaks. The southern pine beetle attacks and kills healthy, vigorous green pines of practically all species and sizes within its range, Shortleaf pine[6] is probably its most favored host, while longleaf pine[7] is least favored and rarely attacked. The only trees not attacked by it are the smaller pines below 2 inches in diameter (breast height) and less than 20 years old. The Ips beetles attack dying trees, recently killed trees, and trees weakened by some other agency. Although insects of this latter group may hasten the death of some trees, they seldom are the cause of it except under unnatural conditions. Trees seriously affected by drought, fire, girdling, or primary insects may be successfully attacked by Ips.

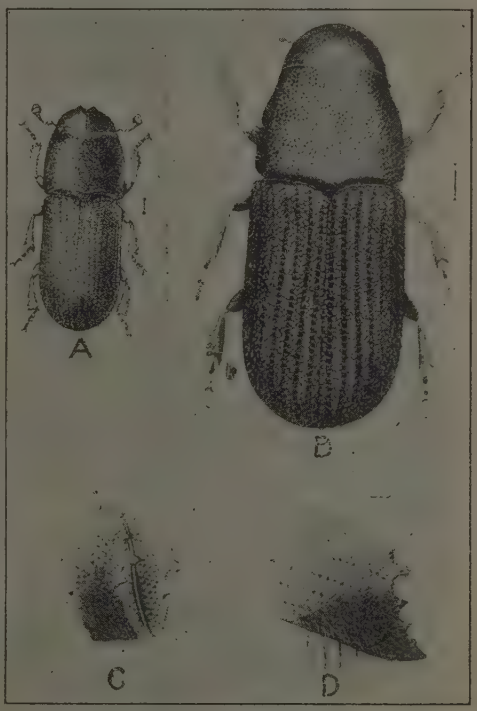


FIGURE 11.—Adult bark beetles: A, The southern pine beetle (note end of abdomen gradually rounded out in a convex manner); B, one of the turpentine beetles similar in shape to A but larger; C and D, parts of Ips bark beetles showing posterior end of abdomen scooped out and armed with toothlike projections. The short lines indicate the natural lengths of the beetles. (B, C, and D after Swain)

The turpentine beetles (fig. 11, B) are similar in form to the southern pine beetle but are about twice as large, being about one-fourth inch in length. They often attack the bases of pines surrounding newly constructed buildings or camps, or anywhere where the cutting or wounding of pines has taken place. They are rarely able to complete their life cycle in green trees and are usually drowned out by the flow of pitch. Normally they breed in stumps and felled logs and are not capable of killing trees. Occasionally, however, they attack weakened, dying, and girdled trees and develop healthy broods in them. In girdled trees they attack below the girdle, where growth has ceased. Trunks of standing trees are seldom attacked by this beetle at points more than 6 feet from the ground. Their work is readily detected, because there are large pitch tubes near the base of attacked trees (fig. 15), and when the bark is removed their long galleries, about a half inch wide and filled with pitch and borings, are exposed. The grubs, working

[6] *Pinus echinata* Mill. [7] *Pinus palustris* Mill.

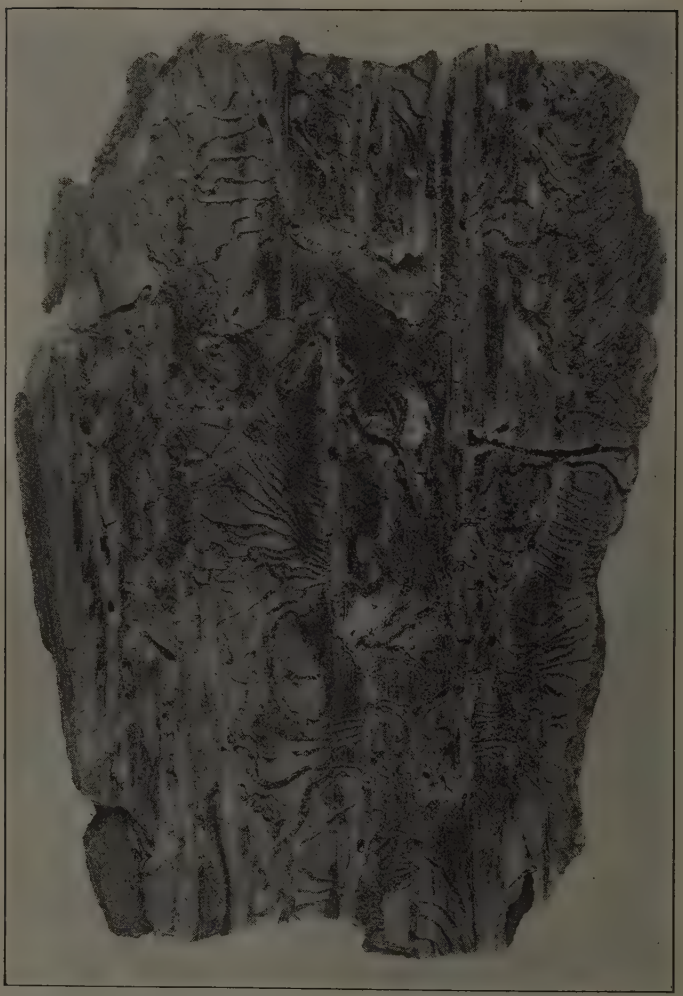


FIGURE 12.—Ips bark beetle gallery in center with long radiating larval tunnels, more or less at right angles to the adult egg tunnel. About two-thirds natural size

together, often completely excavate the soft inner bark around a portion of the base of the tree, thereby causing the outer bark to loosen and fall off. Hopkins [8] has pointed out that this large area, where the wood has been exposed, is often mistaken for a fire scar. These beetles should cause little alarm, as they seldom, if ever, kill the trees.

OTHER BEETLES ASSOCIATED WITH THE SOUTHERN PINE BEETLE

A beetle [9] commonly associated with trees attacked by the southern pine beetle is one of the long-horned beetles, the larvæ of which are known as round-headed borers or, locally, more commonly called sawyers or fish bait. The adult is an elongated beetle about 1 inch in length, of a mottled-gray color. (Fig. 16.) The male has long feelers or horns (antennæ), which are often two or three times as long as the body. The larvæ may be recognized as elongated, footless grubs of a grayish-white color, which vary in size according to the age of the individuals. When fully mature they are about 2 inches long. (Fig. 16, *i*.) Although this beetle is in no way responsible for the death of trees, it quickly reduces the value of the logs for salvage purposes, since it reduces the lumber from the best grades to No. 1 common. The injury is caused by the grubs, which often destroy some of the broods of the destructive pine beetle while working under the bark, but later ruin the sapwood of the logs if it is not salvaged during midsummer within two weeks after the trees begin to die.

FIGURE 13.—Types of galleries of the southern pine beetle and the associated Ips bark beetles in a 10-inch log. Note the star-shaped and straight galleries of Ips bark beetles on left and the serpentine S-shaped galleries of the southern pine beetle on right, as indicated by arrows

[8] HOPKINS, A. D. CONTRIBUTIONS TOWARD A MONOGRAPH OF THE SCOLYTID BEETLES. I. THE GENUS DENDROCTONUS. U. S. Dept. Agr., Bur. Ent. Tech. Ser. 17 (1) : 153. 1909.

[9] *Monochamus titillator* Fab.

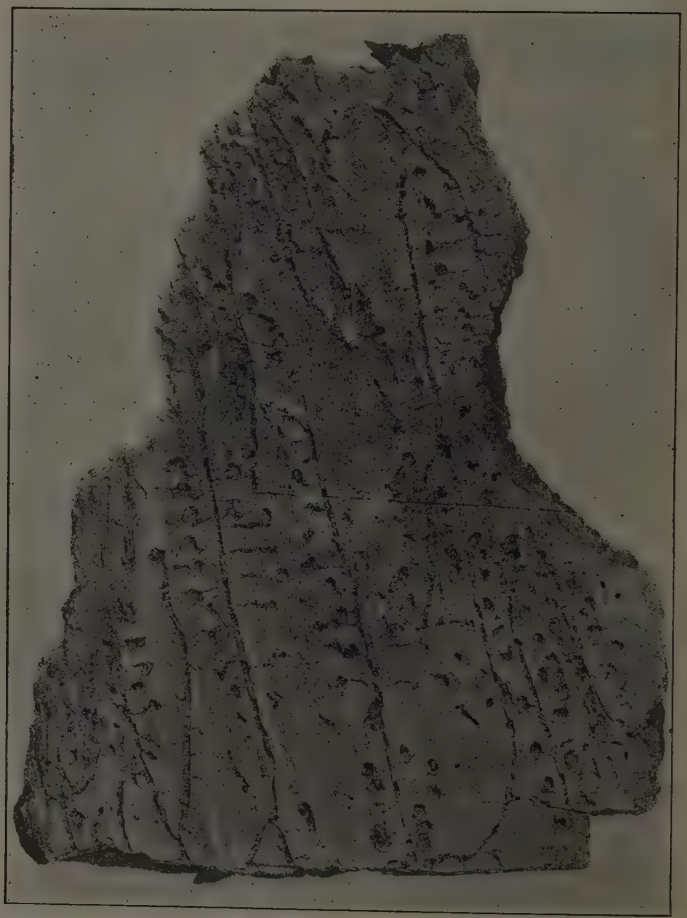


FIGURE 14.—Work of *Ips avulsus* in bark removed from upper part of tree. Note the comparatively straight adult gallery. About natural size

Other grubs, similar in form to the sawyer grubs and often mistaken for them, attack pines already infested by the southern pine beetle, or some other destructive agency, but these are not serious enemies of the southern pine and therefore are not discussed here. Many other bark beetles, most of them smaller species, work in dying and dead pine, but these are not likely to be confused with our most serious enemy of southern pines and therefore need not be mentioned further.

FIGURE 15.—Tubes of the black turpentine beetle within 5 feet of ground. Note that they are much larger than those of the southern pine beetle (fig. 3) usually found farther up the tree. About one-half natural size

NATURAL ENEMIES OF THE SOUTHERN PINE BEETLE

Birds and parasites are agencies which help to preserve the balance of nature. Woodpeckers, especially, have been repeatedly observed destroying the broods of this beetle. (Fig. 17.) Unfortunately these agencies are not present in our forests in large enough numbers to prevent or suppress outbreaks.

PREVENTIVE MEASURES BY FORESTRY METHODS

Outbreaks of the southern pine beetle usually occur in pure, even-aged pine stands, in which the trees are often attacked when only 20 years old. They rarely occur, however,

among pines growing in mixed hardwood stands. General observations throughout the Piedmont region indicate that pure pine stands eventually are transformed to a mixed pine-hardwood composition, because the hardwoods come in in the openings where the pines have been killed by this bark beetle. Wherever possible, the better hardwoods should be encouraged throughout the pure stands of pine so that a mixed type of forest may be developed which will not only be immune to further bark-beetle outbreaks but which also will produce a better grade of softwood lumber. Summer cutting of pines should be avoided whenever possible. Fires in pine areas increase the danger from pine-beetle attack and also destroy the hardwoods within the area, thus tending to create pure pine stands which are always subject to attack.

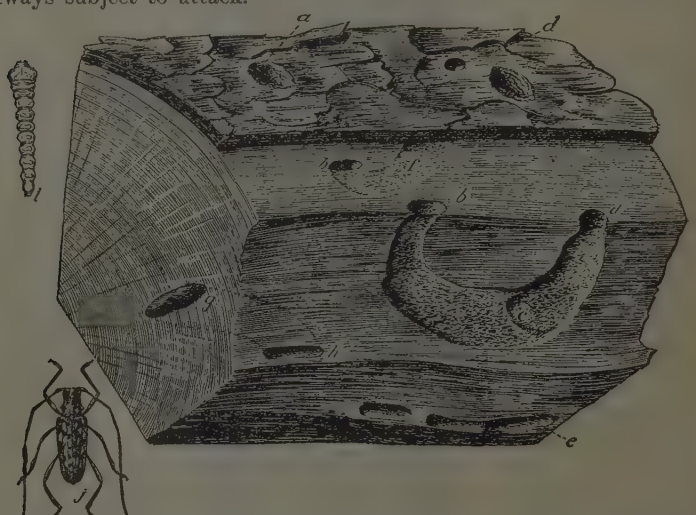


FIGURE 16.—Work of the southern pine sawyer. Section of trunk showing: *a*, Egg pit in bark; *b*, entrance hole of larva into wood; *c*, pupal cell; *d*, emergence hole; *e*, *g*, *h*, sections of larval mines; *f*, scored surface of wood, scoring done by larva preparatory to entering wood; *i*, larva; *j*, adult. Insect one-half natural size. (Webb)

During years of drought pine areas should be carefuly watched for the first evidence of the destructive southern pine beetle, so that measures may be taken to prevent any outbreaks from assuming epidemic proportions.

Since we know that single weakened trees serve as centers of attraction to the southern pine beetle, it is advisable to remove all such trees in order that they may not attract the beetles.

CONTROL MEASURES

Owing to the influence of weather conditions on the southern pine beetle, direct methods of control are recommended with considerable hesitation. It is evident that these beetles increase from a status of rarity to that of destructive abundance in a remarkably short time. On

the other hand, if heavy rains come they disappear quickly and the effort and money spent in control are wasted. It seems reasonable, however, to believe that if the situation were taken in hand at the outset and the insects thoroughly and persistently destroyed, it would be impossible for them to increase as rapidly as if nothing had been done, and considerable timber would thus be saved.

In control work, cooperation between the owners is necessary. It will do little good to clean up one area if timber in areas close to it serves as a source of infestation.

In such control the main objective is to destroy the broods developing in the bark of the tree, thus preventing them from emerging as beetles and destroying other living trees. This can be accomplished by one or another of the following methods:

(1) Felling and logging infested trees and removing the logs to a sawmill, the logs being immediately sawed and the slabs burned. This method is especially recommended where practical, since it permits salvage of the lumber which otherwise would be rapidly destroyed by borers and timber beetles.

FIGURE 17.—Tree attacked by the southern pine beetle. Note holes made by woodpeckers, indicating the high mortality of the brood. Portion of bark removed to show beetle galleries. About three-eighths natural size.

(2) Felling and limbing infested trees in a north-and-south direction and, after they have lain in this position a few days, turning them completely over. This measure is effective only in a well exposed sunny situation during midsummer. The insects under the bark on the exposed side of the log are all killed after about three days of hot sun. The logs are turned so that the

broods under the bark on the opposite side will be exposed to the sun and killed.

(3) Felling and barking infested trees and burning the bark and tops. This method is dangerous in the summer unless extreme precaution be taken to avoid fire. It is, however, a practical control measure in winter.

Whatever the method, it is essential that all the trees containing the living insects be treated. Some of these will still have green foliage or foliage that is only slightly faded, in which case boring dust or pitch tubes on the bark should be looked for as evidence of attack. When the foliage has turned brown, except where it has turned color late in the fall, the insects have already abandoned the trees.

All portions of the main stem up to a minimum of 4 inches in diameter should be treated. The limbs should either be scattered about so that they will be exposed to the sun and quickly dry out, or else they should be burned.

Do not treat trees, except for the purpose of salvage, if the bark shows innumerable small holes such as might be produced by a load of fine shot. The beetles have left the bark of such trees.

Prompt action is necessary. The sooner and the more effectively and persistently the work is carried out, the better will be the results.

Adequate fire protection will do much to reduce the ravages of the beetles, since they are attracted to scorched trees.

INVESTIGATIONS OF OUTBREAKS

The periodic widespread devastations of the southern pine beetle have been responsible for the destruction of more merchantable pine timber in the Southern States than has any other agency. For this reason, extensive investigations have been conducted from time to time to devise measures of control. The most recent facts contributing to a knowledge of the habits of this beetle have been gained as a result of projects carried on at a field station established during 1925, in cooperation with the Forest Service, in the Bent Creek section of the Pisgah National Forest, near Asheville, N. C. Insect studies pertinent to the forest districts of the Piedmont and coastal plains sections of the Southern Atlantic and Gulf States are now being conducted.[10]

[10] Information relating to forest-insect work can be obtained by addressing either the Division of Forest Insects of the Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C., or the Forest Entomological Laboratory, Appalachian Experiment Station, Asheville, N. C.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
U. S. GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY

E&A

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1595

The BOLLWORM OR CORN EAR WORM AS A COTTON PEST

THE BOLLWORM or corn ear worm is an important enemy of cotton, corn, tomatoes, and tobacco. It feeds also on many other cultivated and wild plants.

As the winter is passed in the pupa or resting stage, from 4 to 6 inches below the surface of the soil, late fall or winter plowing will cause the death of many pupae. This is probably the most important of all control practices.

Since the insect increases greatly in numbers late in the season and hard bolls of cotton are largely immune to attack, it is important that the cotton crop be matured as early as possible.

The caterpillar, except when it first hatches from the egg, feeds by boring into the fruit or stalk of the plants attacked; hence poisoning must be done at the right time to give best results. Poisoning of cotton with calcium arsenate, powdered lead arsenate, or Paris green should be done when the ears in the main corn crop become hard; that is, about July 10 to August 20, according to latitude and season.

Corn used as a trap crop gives some protection to cotton. The corn for a trap crop should be planted so as to come into silk and tassel when the ears of the main crop are hardening.

This bulletin is a revision of and supersedes in part Farmers' Bulletin No. 872.

Washington, D. C. Issued June, 1929

THE BOLLWORM OR CORN EAR WORM[1] AS A COTTON PEST

By F. C. BISHOPP, *Principal Entomologist, in Charge of Division of Insects Affecting Man and Animals, Bureau of Entomology*

CONTENTS

	Page		Page
Character of injury	2	Control measures—Continued.	
Habits of the insect and how it develops	4	Protection of cotton fields by poisoning bollworms in other crops	10
Seasonal history and relation of abundance to crop growth	6	Poisoning cotton	10
Control measures	7	Corn as a trap crop to protect cotton	13
Fall and winter plowing	9	Ineffective methods of control	14
Control by cultural practices	9		

COTTON BOLLWORM, corn ear worm, tomato fruit worm, and false budworm of tobacco are common names applied to one and the same insect when it is found attacking these various crops. In fact, the insect is a very general feeder, attacking many wild plants as well as garden vegetables, alfalfa, cowpeas, and the crops indicated above.[2]

This insect should not be confused with the pink bollworm, which is entirely different in habits and appearance.[3]

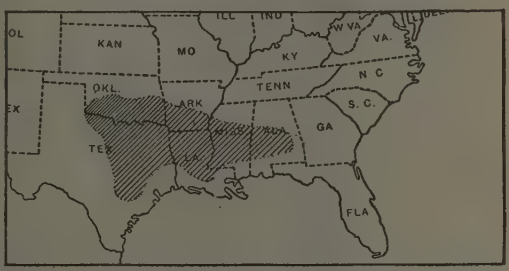


FIGURE 1.—Map showing approximately the area in which the bollworm inflicts severe injury on cotton

The bollworm, or corn ear worm as it is most widely known, occurs as a pest in practically all parts of the United States. The corn crop is widely affected, and the loss to this crop, including sweet corn, is enormous. The average annual loss to cotton on account of its depredations has been estimated at $8,500,000. This injury to cotton is most severe in parts of Texas, Oklahoma, and Arkansas. There is also considerable injury in some seasons in Louisiana, Mississippi, and Alabama. (Fig. 1.) Despite these tremendous losses, the fact

[1] Known scientifically as *Heliothis obsoleta* Fab.; order Lepidoptera, family Noctuidae.

[2] For information on this insect as a pest of corn see the following publication: PHILLIPS, W. J., and KING, K. M. THE CORN EARWORM: ITS RAVAGES ON FIELD CORN AND SUGGESTIONS FOR CONTROL. U. S. Dept. Agr. Farmers' Bul. 1310, 18 p., illus. 1923.

[3] For further information regarding the pink bollworm see the following publications: Hunter, W. D. THE PINK BOLLWORM, WITH SPECIAL REFERENCE TO STEPS TAKEN BY THE DEPARTMENT OF AGRICULTURE TO PREVENT ITS ESTABLISHMENT IN THE UNITED STATES. U. S. Dept. Agr. Bul. 1397, 31 p., illus. 1926. OHLENDORF, W. STUDIES OF THE PINK BOLLWORM IN MEXICO. U. S. Dept. Agr. Bul. 1374, 64 p., illus. 1926.

that the insect has been present as a pest in this country for many years has caused most farmers to become tolerant of it.

FIGURE 2.—Young corn plant showing bollworm injury to growing tip. (Quaintance)

CHARACTER OF INJURY

The character of attack on all the principal crops affected is similar. Where the type of plant growth will permit, the caterpillars usually bore into and feed within the plant tissue. The first damage

to corn is caused by boring into the bud and eating down into the tender leaves as they unfold. (Fig. 2.) A little later this injury often seriously affects the tassels before they have opened out, and when the silks appear eggs are laid upon them, and young corn ear

FIGURE 3.—Bollworm and its injury to an ear of field corn. (Quaintance and Brues)

worms burrow down through the silks and attack the small kernels, as shown in Figure 3. The tips of the ears are injured first; later, especially in tender varieties such as sweet corn, the worms sometimes eat completely to the base of the ear and almost destroy it. In some

regions practically every ear of sweet corn is more or less damaged, and in the cotton States from 70 to 98 per cent of the ears of field corn are attacked.

In the case of cotton the injury is readily distinguished from that caused by the boll weevil (fig. 4), as the squares and more tender bolls are completely eaten out, particularly after the worms have gained considerable size. Occasionally full-grown bolls are gnawed into by the large caterpillars and from one to all of the locks of cotton damaged. (Figs. 5, 6, and 7.) Bolls which have become hard are seldom fed upon to any extent, although the worms, when abundant, have been known to gnaw around the bases of the full-grown bolls and finally to cut off the supporting stems.

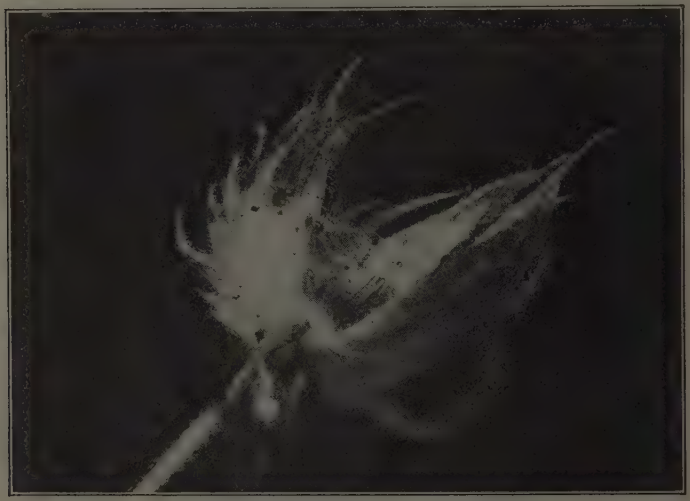


FIGURE 4.—Cotton square partly eaten out by young bollworms. Note web which is evidence of the presence of young bollworms. (Quaintance and Brues)

HABITS OF THE INSECT AND HOW IT DEVELOPS

A general knowledge of the life history and habits of an insect is needed in order to combat it intelligently. The adult of the bollworm or corn ear worm is a moth or miller about 1⅓ inches across the spread wings (fig. 8), ranging in color from a light brown or olive green to pale yellow. It is commonly seen flying about in the evening, and feeds upon nectar of various flowers. When mature a female may deposit from about 500 to almost 3,000 eggs. The eggs are laid on various parts of the plant and to some extent upon weeds and upon the ground. Observations on the distribution of the eggs on the cotton plant show that only 20 to 40 per cent of them are laid on the squares, blooms, bolls, and tender growing tips. They are white or yellowish, oval, and covered with minute ridges running from top to bottom and still smaller ridges across these. (Fig. 9.) They are large enough to be seen readily with the naked eye. The

eggs hatch in from two and one-half to eight days, or the period may be even longer, depending upon the temperature.

When first hatched the larvae or caterpillars are extremely small. They feed here and there on the surface of the plant near where the eggs were laid, but gradually work toward some tender portion within which they can bore. Growth varies with the food supply and temperature, the period ranging from 12 to 70 days. The larvae shed their skins four or five times during this period. When full grown they are about 1½ inches in length. The color varies from

FIGURE 5.—Full-grown bollworm and its work in a large cotton boll. Slightly enlarged. (Quaintance and Brues)

pale green to almost black. During the last few days of active feeding the caterpillar is capable of consuming large quantities of food, and it is during this period that it is most destructive.

When fully fed, the larvae leave the plants and burrow into the ground, where they form cells in which they transform into chrysalids or pupae of a mahogany-brown color. (Fig. 10.) They remain in this quiescent stage for about two weeks, except in the case of the last brood in the fall, which stays in the ground until warm weather the following spring. The depth at which these cells are

formed by the larvae in summer ranges from 1 to 4 inches according to the hardness of the soil. The overwintering pupae are formed at somewhat greater depths, usually from 4 to 6 inches. These chrysalids or pupae produce moths which in turn lay eggs. The life cycle may be completed in as short a period as 30 days in warm weather.

That there is a definite connection between weather conditions and injury to the cotton crop by this insect is generally recognized. Cloudy and rainy weather during the latter part of July and throughout August undoubtedly is conducive to severe injury. This is partially explained by the moistening of the soil, which permits the moths to emerge without difficulty, and by the stimulating effect of the moisture on the growth of stalks and leaves of cotton at this time, which favors bollworm development. Furthermore, it has been found that the prevalence of such weather conditions lessens the

FIGURE 6.—Characteristic appearance of cotton bolls damaged by the bollworm. Note that in the boll on the extreme right one lock of cotton has matured, whereas the other locks are barren. (Quaintance and Brues)

effectiveness of certain minute parasites which prey upon the bollworm in the egg and larval stages.

SEASONAL HISTORY AND RELATION OF ABUNDANCE TO CROP GROWTH

As has been stated, the bollworm, or corn ear worm, pupa passes the winter months in the soil in the cotton States. Early in the spring the moths begin to come out, and by the time corn is knee-high they are ready to deposit eggs. On account of the number of pupae which die from adverse conditions in the winter, the first generation usually is small, and the damage is not so appreciable. The second generation appears about the time the corn is in silk and tassel, and the number of moths is greatly increased. The caterpillars of that generation reach their full development about the

time the ears of early corn become hard. In the South the third generation is the one which is destructive to cotton, the corn at that time being for the most part hard and dry. In that region four, or even five, generations may develop during a year. The late caterpillars feed on various green crops, including late cotton, cowpeas, and alfalfa. Thus in the Southern States most of the overwintering insects will be found in soil where cotton and other late-growing crops are raised.

The bollworm shows a preference for corn when the corn is silking, and this fact can be utilized to some extent in protecting cotton and other crops from injury, as will be pointed out later. These caterpillars are cannibalistic, and when they come in contact with one another many of them are killed, which usually reduces the number of worms developing in a single ear to one, two, or at most three, whereas dozens of eggs may be laid upon a single strand of corn silk.

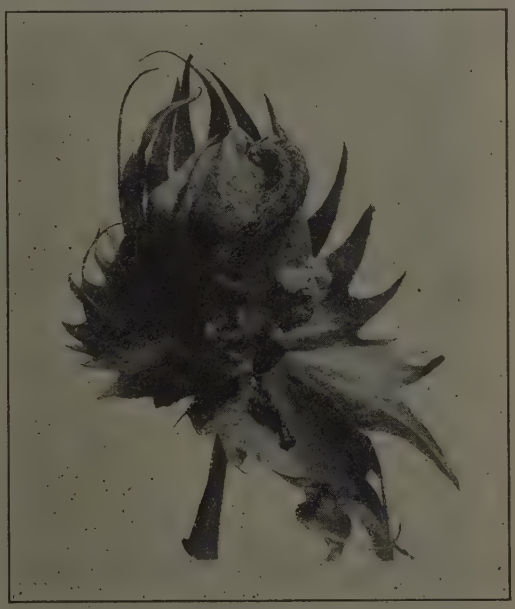


FIGURE 7.—Full-grown bollworm eating into the tip of a cotton boll. Natural size. (Quaintance and Brues)

CONTROL MEASURES

As a result of the study of the life history and the seasonal history of this insect it will be seen that there are four outstanding facts which can be made use of in control work: (1) The insects spend the winter in the pupal stage in the ground. The summer generations also spend some time (about two weeks) in the pupal stage in the ground. This enables the farmer to destroy many of them by plowing at the proper time. (2) The caterpillars feed for a time on the surface of the leaves before penetrating the tissues of the plant. This is the only time during which the insect can be poisoned successfully. (3) The number of bollworms or ear worms increases greatly as the season advances. This indicates a need for hastening the maturity of all crops affected. (4) Since green corn is preferred as food, it is possible to utilize this to some extent as a trap crop to protect cotton and other crops.

It has been found that by modifying slightly the usual farm practices much can be done toward lessening bollworm or corn ear worm injury. Fortunately these modifications are such as to increase crop

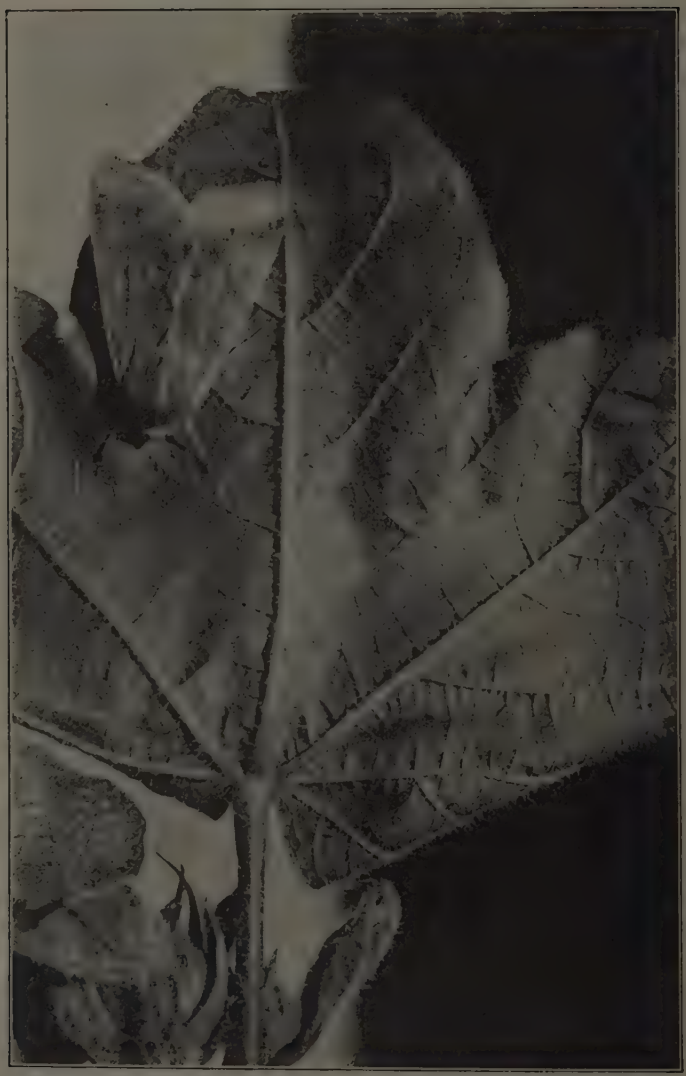


FIGURE 8.—Bollworm moth at rest on cotton leaf. About twice natural size. (Quaintance and Brues)

production, regardless of the presence of this insect. Another important point is that some of the recommendations for controlling this insect are equally applicable, irrespective of the crop grown.

FALL AND WINTER PLOWING

Probably the most important single step in controlling the bollworm consists in the thorough breaking, at some time during the late fall or winter months, of the land in which the worms have buried themselves for the winter. Particular attention should be paid in this respect to land that has been in crops which are known to harbor bollworms during the late fall months. The practice of fall and winter plowing, aside from bollworm control, is desirable because it conserves moisture, puts the ground in better condition for planting, and enables the farmer to plant at the proper time the following spring.

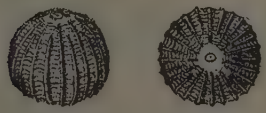


FIGURE 9.—Egg of bollworm moth, side and top views. Enlarged 30 diameters. (Quaintance and Brues)

FIGURE 10.—Vertical section through soil, showing pupa of bollworm in its burrow. About natural size. (Redrawn from Quaintance and Brues)

It has been found that the breaking up of the cells in which the insects are spending the winter results in the destruction of practically every pupa through the action of cold and moisture. Since the cells of the wintering brood are formed at from 4 to 6 inches beneath the surface, it is important that the plowing be deep enough to reach them. It is desirable to plow or deeply disk the fence rows and other places where bollworms may have fed on various plants. This is also beneficial in destroying eggs of grasshoppers and the hibernating places of chinch bugs and other destructive insects.

CONTROL BY CULTURAL PRACTICES

Several of the measures best calculated to reduce bollworm injury in the cotton-growing States are equally effective in checking

the ravages of the boll weevil. No loss of money or energy results from putting such cultural practices into effect, even though the bollworm should not appear in very destructive numbers in any particular year.

To protect cotton from bollworm injury it is important (1) that seed of early-maturing cotton be selected; (2) that the crop be planted as early as is consistent with getting a good stand and having the crop start off well; (3) that poor lands be fertilized and cultivation be thorough and frequent. Every step should be taken which will hasten the early maturity of fruit and keep the plants in a healthy, growing condition. The reason for this can be readily seen since we know that the bollworms pass to the cotton when the corn becomes mature, and that hard bolls are less subject to injury. As the moths hide in the foliage when the growth is luxuriant, those varieties which make comparatively small stalk without a superabundance of leaves are desirable. This also hastens the drying out of the bolls after they are grown. The early and complete destruction of cotton stalks, as recommended for boll-weevil control, will prevent the maturity of many late bollworms and destroy a considerable number outright.

The growing of all corn in a single block, rather than scattering it over the plantation, is advised.

PROTECTION OF COTTON FIELDS BY POISONING BOLLWORMS IN OTHER CROPS

When bollworms are found to be present in large numbers on alfalfa, vetch, or cowpeas before cotton is well matured, poisoned bran mash may be used to advantage. This is made as follows: Wheat bran, 50 pounds; Paris green or white arsenic, 1 pound (or powdered calcium arsenate, 2 pounds); low-grade molasses, 2 gallons; water, 3 to 4 gallons. The bran and insecticide are first mixed together dry, the molasses and water are then added, and the whole mass is thoroughly mixed. The mash should be broadcast thinly over the fields. An application of 10 pounds of bait per acre is ample. It is preferable to scatter the bait late in the evening.

Calcium arsenate applied as a dust to such infested fields is also effective, and there is no danger of poisoning stock if only one application of 5 pounds per acre is made and if the forage is exposed to a good rain before being harvested. The standard calcium arsenate as used against the boll weevil is generally available and reasonable in price. The distribution should be thorough. There are a number of standard types of cotton-dusting machines on the market, and any of these may be used for making the application. For large areas the employment of an airplane properly equipped as for dusting cotton may be advisable.

POISONING COTTON

The use of poisons against the bollworm has met with considerable success where the poisons have been applied at the proper time. Dusting cotton with calcium arsenate is now a standard control measure for the cotton boll weevil. Where the boll weevil and bollworm occur in destructive numbers in the same fields the two insects may be combatted simultaneously by this method.

Attention has been directed to the fact that a large proportion (from 60 to 80 per cent) of the eggs of the bollworm deposited on cotton are placed elsewhere than on the squares, flowers, and growing tips. Following hatching, therefore, it is necessary for the young larvae to travel a considerable distance before penetrating the fruit. During this rather aimless wandering the insect eats here and there from the surface of the leaves and stalks. Throughout this short period in the existence of the larva it may be poisoned by eating some of the insecticide.

The importance is emphasized of getting the poison on the plants when the numerous young larvae of the August generation begin to hatch and not after the larvae have grown to considerable size. In the later stages they have burrowed into the squares and bolls and are not feeding on the surface where the poison has been deposited.

The time for applying the poison to cotton varies slightly from year to year. The first application should be made when the corn ears are becoming hard. The actual date will range from about July 10 to August 20, according to latitude and seasonal conditions. Close examination of the cotton plants at this time will show the earliest-hatched bollworms making minute holes in squares. Often their presence may be detected by the delicate webs which the young worms sometimes spin about the squares.

Calcium arsenate, powdered lead arsenate, or Paris green may be used for poisoning, but since the department is advocating the use of calcium arsenate against the boll weevil, and since that product is being prepared especially by chemical companies for use on cotton, it is readily available and has an advantage over Paris green in not burning the cotton plants and in being less dangerous to apply. It is more poisonous to insects than lead arsenate and is much cheaper. However, during recent years several instances have been noted in which severe bollworm injury developed on cotton which had been poisoned sufficiently for boll-weevil control. In some cases this was evidently due to the fact that dusting ceased before the bollworm migrated to the cotton, but in others some other explanation is needed, and this problem is the subject of a special investigation now being conducted by the Bureau of Entomology.

While it is possible to apply poison to cotton in the form of a spray (Paris green 1 pound, water 50 gallons), this method is usually impractical, and dust applications are advised. If Paris green is used it is best to mix it thoroughly with some carrier, such as air-slaked lime in the proportion of 1 pound of Paris green to 3 pounds of the carrier, and make application at the rate of from 6 to 9 pounds of the mixture per acre, according to the size of the plants.

If calcium arsenate is used, a standard cotton-dusting grade, such as is sold for boll-weevil control throughout the South, should be obtained, and it should be applied, without any other substance added, at the rate of from 4 to 5 pounds per acre. This is a very light fluffy powder which forms an excellent dust if blown on the cotton with force.

The method of application should depend on the acreage to be treated. For poisoning small areas up to about 25 acres hand dust guns, which are on the market, may be used. About 3 acres a day

can be covered by one of these. For larger acreages wheel-traction dusters (fig. 11) are obtainable, and for very large areas power dusters may be advisable.[4]

Some may prefer the old-fashioned method of applying poison with a bag and pole. This method lacks thoroughness and, while satisfactory for controlling the leaf worm, it does not give best results against the bollworm. This equipment may be carried across the back of a mule, the poison being jarred out through the bags by movements of the animal and by tapping the pole. The construction of one of these outfits is very simple. Rectangular cloth bags are nailed to either end of a 4-inch board of a length equal to the distance between two cotton rows, as is shown in Figure 12. For dusting with Paris green 8-ounce duck should be used, and for calcium arsenate domestic is satisfactory.

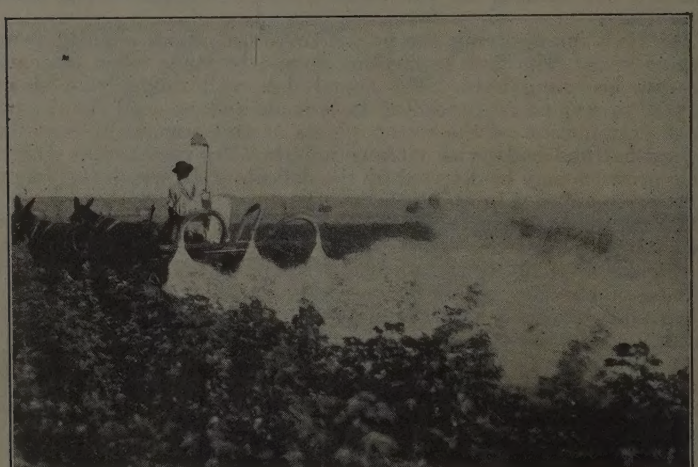


FIGURE 11.—A wheel-traction duster distributing calcium arsenate on cotton plants for the control of the bollworm

To get best results the dusting should be done when the plants are covered with dew. This usually necessitates making the application during the night or in the early morning hours. Windy periods should be avoided.

It should be remembered that all of these arsenicals are poisonous to man and animals, although they are not dangerous if properly handled. Calcium arsenate is less injurious to man than Paris green. Men employed in distributing the poison should change their clothes and bathe immediately after ceasing work. No case of poisoning of animals used in drawing the machines has been observed, but if they are inclined to eat the cotton plants it is best to safeguard them by using muzzles.

[4] For discussion of dusting machinery for boll-weevil control see the following publications: JOHNSON, E., HOWARD, S. T., and COAD, B. R. COTTON-DUSTING MACHINERY. U. S. Dept. Agr. Farmers' Bul. 1319, 20 p., illus. 1923. COAD, B. R., JOHNSON, E., and MCNEIL, G. L. DUSTING COTTON FROM AIRPLANES. U. S. Dept. Agr. Bul. 1204, 40 p., illus. 1924.

The number of applications should depend largely on the abundance of eggs deposited during the few weeks following the first application. Some years the bollworms appear in great numbers at one time, but in other seasons they are more or less distributed through the late summer. On the average it is believed that two applications of poison 7 to 10 days apart will give the best results. If a heavy rain should follow within 24 hours after an application another treatment should be given. After the poison is well dried on with the dew it will withstand considerable rain.

In rather extensive experiments in the use of Paris green against the bollworm, the use of the poison resulted in a gain per acre of $5.21 over the return from undusted fields, even after the cost of the poison and the expense of application had been deducted. Some of the fields were treated once and others received two applications.

Although the approved method of using poison dust for control of the bollworm is somewhat different from that for control of the boll weevil, a high degree of control of the bollworm should ordinarily result in sections where poisoning of the boll weevil [5] is practiced. Where the boll weevil and bollworm are both frequently numerous an attempt should be made to follow the infestations in the fields closely enough to make applications of the poison at the proper time to check the ravages of both of these pests.

In most districts, on account of the sporadic occurrence of bollworms in great numbers, it is rather difficult to foresee just when

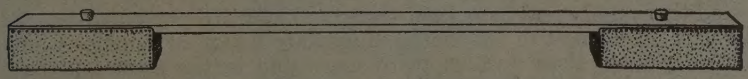


FIGURE 12.—Bag and pole for use in distributing poison in bollworm control

serious injury will occur, but it would no doubt be profitable to apply poison each year in the portions of Texas and Oklahoma where bollworm damage is general and more severe.

CORN AS A TRAP CROP TO PROTECT COTTON

Since the bollworm prefers corn to cotton or most other plants for food, it is possible to concentrate the larvae on corn and keep them from becoming so numerous on cotton. To effect such a result, it is important that the trap corn be planted at such a time as to be in silk and tassel about the time the main crop of field corn becomes hard, which is usually near the first of August. If it matures too early, it will act only as a breeding place for bollworms, which will mature as the ears harden and a short time later transform to moths which in turn will deposit eggs over adjacent cotton fields. On the other hand, if the plants are in an attractive state, the moths, which fly quite freely, will assemble in the corn from considerable distances and deposit most of their eggs on the corn plants. These eggs will hatch and the young larvae, being so numerous, will destroy one another to such an extent that usually not more than a few out of the many hatching on the silk of each ear will reach maturity.

[5] The poisoning of the boll weevil is discussed in the following publications: COAD, B. R., and GAINES, R. C. POISONING THE COTTON BOLL WEEVIL. U. S. Dept. Agr. Leaflet. No. 37, 4 p. 1929. HUNTER, W. D., and COAD, B. R. THE BOLL-WEEVIL PROBLEM. U. S. Dept. Agr. Farmers' Bul. 1329, 30 p., illus. 1923.

One plan of planting the trap rows consists of leaving belts from 10 to 40 feet wide across the field at the time the cotton is planted and about June 1 planting this space with Mexican June corn in rows 5 or 6 feet apart. About 10 days later a row of cowpeas may be planted between the corn rows, room thus being left for cultivation and at the same time furnishing attractive places for the bollworm moths, which will concentrate in the trap rows in great numbers.

Another system is to plant larger patches of June corn and cowpeas here and there over the plantation, following such crops as oats, wheat, and potatoes. This has some advantage over the plan just outlined, as the larger areas of corn appear to permit less egg laying on the adjacent cotton than where narrow strips are used, and in addition the land is more fully utilized. As far as possible the trap crop should be located between the early corn and the cotton.

Either of these systems provides a trap crop for the bollworm, and often makes possible a good yield of corn and a crop of cowpeas which is valuable as green manure or for food and forage. While any variety of corn may be used, the Mexican June corn is more desirable in the Southwest on account of its resistance to drought.

INEFFECTIVE METHODS OF CONTROL

The burning of lights to attract the moths in the fields is not uncommon in certain sections, and the idea of trapping the moths by various devices is often advocated. Both of these methods have been tested thoroughly and have been found to be of little or no value. In the first place, most of the moths caught are males, or females which have deposited their full quota of eggs, and in the second place a great many beneficial insects which prey upon the bollworm in different stages are destroyed. The placing of poisoned sweets in pans in the cotton field also has been found to be a useless practice.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
U. S. GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY

▽